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ON THE HISTORY OF SEWAGE DISPOSAL ENQUIRIES.

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An Address,

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PROFESSOR W. H. CORFIELD, M.A., M.D. (OXON), F.R.C.P.,

President of the Society of Medical Officers of Health,

AT A MEETING OF THE SOCIETY, HELD ON
OCTOBER 19, 1888.

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ON THE HISTORY OF SEWAGE DISPOSAL ENQUIRIES.

Address of the President,

Prof. W. H. CORFIELD, M.A., M.D. (Oxon), F.R.C.P.,

19th October, 1888.

GENTLEMEN,—I wish in the first place to express to you my high sense of the honour you have done me in again, after so short an interval, electing me your President, and to assure you that I shall spare no effort to make my year of presidency a successful one, and that I have no doubt I shall do so, assured as I am of your cordial support; although I cannot hope that anything so important to the Society will take place in the ensuing session as the union of the various Societies of Medical Officers of Health into one great Society, which has been accomplished during the period of office of our late President.

In considering what subject I should select for an address to you on this occasion, it has occurred to me that as I formerly spoke to you on the History of House Sanitation, I might not unfitly follow up that address with one on the History of Sewage Disposal Enquiries, not only because on general grounds the subject of Sewage Disposal is of the highest importance to all civilised communities, but also because, from having been for seven years a member of and reporter for the Committee appointed by the British Association to enquire into the Treatment and Utilisation of Sewage, I was led to pay especial attention to this matter, and to write some eighteen years ago a treatise on the subject, the third edition of which I was enabled to get through the press last year, thanks to the aid of my friend and our associate Dr. Louis Parkes.

I have not been unmindful of the fact that our late President gave us an address two years ago on "The Existing Methods of Refuse Disposal in Towns," but I propose to look at the subject from a different point of view, by tracing the history of the investigations which have led up to our present knowledge of the matter; and I venture to think that this will be particularly useful just now, as we are too apt to forget what has been done by others before, and to embark on enquiries and investigations as if we were commencing *de novo*, and without paying due regard to experience already acquired. This is especially the case with the methods proposed at various times for the treatment and utilisation of sewage, as it has over and over again happened that a process which has been tried once and demonstrated to be not only a failure but of necessity so, has been brought forward again and foisted with the greatest confidence on an unsuspecting and imperfectly informed public.

I do not think it necessary to do more than make a passing allusion to the practice of past centuries, which was to collect the more solid refuse matters in and around the houses, and to construct drains to convey the surplus water, more or less foul, to the nearest water course; this was the plan adopted in ancient Rome, and has been followed in most countries up to the present time. The evils attending it are well known to you all—pollution of air, pollution of water in wells, pollution of soil, with their attending outbreaks of disease, and to a certain extent also pollution of rivers. I say to a certain extent, because this, which has become so serious an evil in our own time, was before 1815 partly obviated by regulations forbidding owners of property from connecting cesspools and middens with the public drains.

But with the introduction of water-closets in the last century, and more especially with their general adoption in this, a new state of things arose; people finding it most convenient to connect their water-closets with the drains did so, thus converting these drains into sewers conveying fæcal matter as well as dirty water into the water courses, the water of which was in most instances used for domestic purposes by those living lower down the streams. The great increase in the size of our towns in recent times intensified this evil, and it has grown until the question of the disposal of the sewage of large towns has forced itself upon us as one of the most important, if not the most important, of the sanitary problems of the day.

We all acknowledge the veteran sanitarian, Mr. Edwin Chadwick, as the pioneer of sanitary improvements in this direction, and I will in the first place draw your attention to his memorable report made for the Poor Law Commission, on the Sanitary Condition of the Labouring Population of Great Britain, in the year 1842. In this report, after investigating a vast amount of evidence, Mr. Chadwick comes to the following conclusions, among others, "as to the means by which the present condition of the labouring classes may bo improved"—

"The primary and most important measures, and at the same time the most practicable, and within the recognised province of public administration, are drainage, the removal of all refuse of habitations, streets, and roads, and the improvement of the supplies of water.

"That the chief obstacles to the immediate removal of decomposing refuse of towns and habitations have been the expense and annoyance of the hand labour and cartage requisite for the purpose.

"That the expense may be reduced to one-twentieth or to one-thirtieth, or rendered inconsiderable, by the use of water and self-acting means of removal by improved and cheaper sewers and drains.

"That refuse when thus held in suspension in water may be most cheaply and innoxiously conveyed to any distance out of towns, and also in the best form for productive use, and that the loss and injury by the pollution of natural streams may be avoided.

"That for all these purposes, as well as for domestic use, better supplies of water are absolutely necessary."

It will thus be seen that he, at this early period, insisted on the importance of removal of refuse matters from the neighbourhood of habitations, and pointed out that the cheapest and most effectual way to do this was by means of the water carriage system of sewerage.

In the same report an account is given of the utilisation of the sewage of Edinburgh by irrigation. From this account we gather that although the process was conducted in such a manner as to be a serious nuisance, the agricultural value of sewage as a manure was fully proved, as shown by the following quotation :—

"The rent for which some of these meadows are let in small portions to cow-feeders varies on an average from £20 to £30 per acre. Some of the richest meadows were let in 1835 at £38 per acre, and in that season of scarce forage, 1826, £57 per acre were obtained for the same meadows. . . . . The waste land called Figget Whins, containing 30 acres, and 10 acres of poor sandy soil adjoining them, were formed into water meadows in 1821, at an expense of £1000. The pasture of the Figget Whins used to be let for £40 a year, and that of the 10 acres at £60. Now the same ground as meadows lets for £15 or £20 an acre a year, and will probably let for more, as the land becomes more and more enriched."

And the conclusion was arrived at that "the process of applying manure by irrigation—that is, separated and diluted with water, is considered to be productive of less deleterious gas, of less injurious effects, than by spreading it over fields in a solid form and allowing it to remain until it is decomposed and separated by the atmosphere and conveyed into the soil by rain. . . . . By irrigation, by the diffusion and conveyance of the manure to the plant in the medium of water, the escape of the valuable substance as a noxious and injurious gas is diminished. . . . . The simple offensiveness, it may be assumed, is a sufficient ground of exclusion of any process from amidst the habitations of a town population. But at a reasonable distance the use of dung or any other manure would not be forbidden; and the process which is the least injurious, the irrigative, is entitled therefore to a preference. Effective drainage must make way for the conveyance of diluted manures and consequently for effective irrigation."

Shortly afterwards the Health of Towns Commission was appointed, and issued two important reports in 1844—45. They began by sending out a list of enquiries to 50 towns in England as to the condition of their drainage, and they stated the result in their first report as follows :—

"It appears from the unanimous statement of the visiting Commissioners, in addition to an examination of the replies of the 50 towns on the subjects of drainage and cleansing, that in scarcely one place can the drainage or sewerage be pronounced to be complete and good, while in 7 it is indifferent, and in 42 decidedly bad as regards the districts inhabited by the poorer classes. The investigations within the several towns of the arrangements for house as connected with street cleansing, present nearly the same results."

"It appears that the local statements and opinions on what is deemed to be good, can only be received with reference to the imperfect standards known in those places. In the answers it is often stated that the drainage of a town is good, where it has been found that only the principal streets have main drains or sewers, and where the houses in those streets are but imperfectly provided with house or branch drains ; while the most crowded portions of the town, those most densely inhabitied by the poorer classes, are utterly neglected, and have no drainage, the refuse being allowed to accumulate and decompose in open channels and pools, or to run into open and stagnant ditches in the immediate vicinity of the houses."

They also stated that they were directing their enquiries "to the subject of the advantage to be derived from the sale and improved application of the refuse and sewage of towns to the purposes of agriculture ;" and in the second volume of their first report published an account of the application of the sewage of Milan to agriculture by irrigation.

In this account the most important points mentioned are the value of the land irrigated to which "a great portion of the agricultural wealth of Lombardy is to be ascribed;" and the fact that the sewage water "possesses also the valuable peculiarity of protecting from frost the meadows it irrigates, owing to the high temperature it receives in its passage under the town."

In their second report the Health of Towns Commissioners stated as their opinion "that new legislative measures, applicable to all towns and populous districts, are required, for the introduction and maintenance—not only of an efficient and economical system of house-drainage and sewerage, paving and cleansing, in all towns and populous districts, but also for providing ample supplies of water for public and private purposes, and for the adoption of other means for promoting and securing the health and comfort of the inhabitants—and embodied a series of most important recommendations of which those immediately concerning our present subject are as follows:—

"That in all cases the local administrative body appointed for the purpose have the special charge and direction of all the works required for sanitary purposes, but that the Crown possess a general power of supervision.

"That before the adoption of any general measure for drainage, a plan and survey upon a proper scale, including all necessary details, be obtained, and submitted for approval to a competent authority.

"That, upon representation being made by the municipal or other authority, or by a certain number of the inhabitants of any town or district, or part thereof, setting forth defects in the condition of such place, as to drainage, sewerage, paving, cleansing, or other sanitary matters, the Crown direct a competent person to inspect and report upon the state of the defects, and, if satisfied of the necessity, have power to enforce upon the local administrative body the due execution of the law.

"That the management of the drainage of the entire area, as defined for each district, be placed under the jurisdiction of one body.

"That the construction of sewers, branch sewers, and house drains, be intrusted to the local administrative body."

In the second volume of their report an important paper is published "on the application of sewer water to the purposes of agriculture," in which the results of analyses of sewage purified by surface irrigation at Edinburgh are given, showing more especially the diminution in the amount of solid matters in suspension, and in the amount of sulphuretted hydrogen in solution in the water; and the remark is made "that the offensive smells complained of by some of the neighbouring inhabitants, as arising from the meadows, emanated mainly from the masses of decomposing matter left in the ponds, and not so much, if at all, from the water holding only fertilizing matter in solution." The paper concludes as follows:—

"Taking a general view of the subject, we may safely assume a clear revenue from the sewer-water of all towns of £1 for each inhabitant, either in a direct money return, or partly to the inhabitants in a reduced price from the increased abundance of produce; and it is obvious that such income annually accruing will provide a sufficient fund for the improvement of all towns in a manner corresponding to the most enlightened views with respect to sanitary regulation and improvement of the present time, and will remain as a source for accomplishing such further improvements as science and practical experience shall from time to time suggest.

"Obstacles, both moral and physical, will no doubt be found in the way, but none certainly more formidable than such as were opposed to the introduction of gas for lighting towns. At present the sewer water of towns is unappropriated, and although all contribute to its production, none claim therein a right of property. It is in principle and in origin public property, and having an important value, it becomes the duty of the guardians of the public interests to take steps, in the first place, for the investment of all sewer-water for the public interest, and thereafter to provide legal facilities for rendering it practically available. Some time will elapse before the public in general see and fully appreciate the merits of this scheme, and no great heed will be given to it, until at least one town, or section of a town, shall have put the plan into actual operation ; but so soon as that shall have been accomplished there will be a general desire to adopt the plan, and there will be no difficulty in finding ample capital for the purpose. The great outlets of the sewerage of most towns can with little difficulty be adapted to the appropriation of the sewer-water for agricultural purposes, and the internal and more minute sewerage can afterwards be carried to comparative perfection by the funds which will arise from such appropriation.

"With such command of funds as the application of the sewer-water will afford, the structural improvement of towns will proceed with a steady progress unfettered by private interests, and uninfluenced by popular clamour."

Although subsequent experience has not justified so enthusiastic a forecast, I quote it as showing how thoroughly those who were working at the subject more than 40 years ago were pointing out to us the right direction.

We now come to the report of the General Board of Health "On the Practical Application of Sewer Water and Town Manure to Agricultural Production," which was ordered to be printed in December 1851.

The most important conclusions arrived at by that Board were that it was essential to the health of towns that waste excretal matters should be removed speedily; that the most complete as well as economical method of removal was that of removal by water; "that the applications of a considerable proportion of the manures of towns in the liquid form—that is to say, as sewer-water, have produced heavier crops than any other known description of manure; and that the superiority of a fourfold production of grass above the ordinary growth on similar soils has been maintained for upwards of half a century by means of the application of the sewer manure near Edinburgh and Milan; that the like increase of fertility has been obtained by a similar application of the common farm manures, in the liquid form.

"That the great increase of the fertilizing power of manures by their proper application in the liquid form has been displayed on various descriptions of soil, on sands, as well on clays and loams, laid down with various descriptions of arable cultivation, but more particularly with green crops, and that the quality as well as the quantity of the produce have been improved.

"That the ordinary augmentation of produce by the full application of the fertilizing powers of liquefied or liquid manures on grass land has been four and five fold above the ordinary amount of production in this country.

"That the chief advantages of the application of manure in the liquid form consist in the economy of the manure, in the promptitude of its action, in the prevention of the loss which occurs by its drying when applied in the solid form, in the like prevention of injurious emanations while it is preserved in solution in water, and in its being better fitted for quick absorption, and more readily carried beneath the surface of the soil to the roots of plants.

But they advised the "distribution of the liquid manure by steam power through fixed and flexible pipes, by jets, or by shedding," a method it has not been found advantageous to adopt.

In their report published the following year "On the Removal of Soil Water or Drainage of Dwelling Houses and Public Edifices, and for the Sewerage and Cleansing of the Sites of Towns," the General Board of Health, while confirming the conclusions adopted in previous enquiries, insisted on the superiority of pipe over brick sewers for the drainage of houses and towns, and concluded that "it is important for the sake of economy, as well as for the health of the population that the practice of the removal of refuse in suspension in water, and by combined works, should be applied to all houses, especially to those occupied by the poorest classes."

In 1858 the Royal Commission appointed to enquire into the best mode of distributing the sewage of towns and applying it to beneficial and profitable uses, issued their first report, in which they came to the following conclusions :—

"1. That the increasing pollution of the rivers and streams of the country is an evil of national importance, which urgently demands the application of remedial measures ; that the discharge of sewage and other noxious refuse of factories into rivers is a source of nuisance and danger to health ; that it acts injuriously not only on the locality where it occurs, but also on the population of the districts through which the polluted rivers flow, that it poisons the water, which in many cases forms the sole supply of the population for all purposes, that it destroys fish ; and, generally, that it impairs the value and the natural advantages derived from rivers and streams of water.

" 2. That this evil has largely increased with the growing cleanliness and internal improvements of towns as regards water-supply and drainage ; that its increase will continue to be in direct proportion to such improvements, and, that as these improvements are yet very partial, the nuisance of sewage, already very sensibly felt, is extremely slight as compared to what it will become when sewerage and drainage works have been carried into full effect.

" 3. That, in many towns, measures for improved water supply and sewerage are retarded from the difficulties of disposing of the increased sewage which would result from them, that the law which regulates the rights of outfall is in an anomalous and undefined condition ; that judicial decisions of a conflicting character have been arrived at in different instances ; and, that consequently the authorities of towns have constantly before them the fear of harassing litigation.

" 4. That the methods which have been adopted with the view of dealing with sewage are of two kinds ; the one being the application of the whole sewage in its crude state to land, and the other, that of treating it by chemical processes, to separate its most offensive portions ; that the direct application of sewage to land favourably situated, if judiciously carried out, and confined to a suitable area, is profitable to persons so employing it, that where the conditions are unfavourable, a small payment on the part of the local authorities will restore the balance.

"5. That this method of sewage application, conducted with moderate care, is not productive of nuisance or injury to health.

"6. That when circumstances prevent the disposal of crude sewage by direct application to land the processess of precipitation will greatly ameliorate and practically obviate the evils of sewage-outfalls, where there is the sea, or a large river for the discharge of the liquid; that such methods of treating sewage do not retain more than a comparatively small portion of the fertilizing matter, and, that although in some cases the sale of the manure may repay a portion of the cost of production, solid manure manufacture is not likely to be successful commercially.

"7. That, considered merely as the means of mitigating a nuisance, these precipitating processes are satisfactory, that the cost of them in any case is such as town populations may reasonably be called upon to meet; that the necessary works need not, if properly conducted, be a source of nuisance, and that, by modifications of the existing methods, even the slightest risk of nuisance may be entirely obviated.

"8. That the employment of the one or other method of disposing of sewage, or of both conjoined, must depend upon locality, levels, markets, and a variety of other circumstances, and that the case of each town must be considered upon its own peculiarities.

"9. That there is good ground for believing that the methods yct proposed for dealing with sewage are not the best that can be devised, and that further investigation will probably result in the discovery of processes more thoroughly equal to the suppression of nuisance, and at the same time calculated to give more valuable products.

" 10. That the magnitude of a town presents no real difficulty to the effectual treatment of its sewage, provided it be considered as a collection of smaller towns." And they added :—" As, however, the conditions under which the evil may be best removed will differ greatly in different localities, we think it would be desirable, before any legislation takes place on this subject, that investigation should be made into the state of the outfalls of different classes of towns, and of the condition of rivers in populous districts, with the view to advise as to the general legistative measures that might safely adopted."

In their second report, issued in 1861, they stated among others the following conclusions from their further investigations :—

" That although one of the chief causes of this pollution is the practice of discharging crude sewage, as it comes from towns, into the nearest rivers or watercourses, thus converting them into sewers, yet, the pollution from this cause is by no means confined to towns which have adopted systematic measures for improved sewerage. Nor is the amount of pollution in proportion exclusively to the completeness of such works; for, in many of the towns in which the bulk of the foul refuse is still retained in cesspools and middens, the neighbouring rivers are in a highly offensive and noxious condition,—even where the cesspool system is maintained on the alleged ground of preserving the local rivers from contamination.

" That by far the greater part of the solid matter which is held in suspension in water is readily deposited in rivers, covering the banks with mud, permanently raising the beds, gradually destroying the scouring power of the water, and partially silting such rivers up; and in some instances these deposits have accumulated to such an extent as to impede navigation, to render the surrounding country subject to floods, and to entail a vast expense in periodic cleansing.

"That however the appearance of the water may be improved after these deposits have taken place, yet the deposited matters, lying in the bed of the current, are under conditions favourable for putrefaction. And when the foul mud is disturbed by the prevalence of rain, and during floods, it sends forth its effluvia amidst the populations which are near, and even in the course of the river far distant.

"That this condition of rivers is a public and national nuisance, it interferes with the convenience and comfort of all classes of the people; it damages various and important interests, as those connected with manufacturing establishments, canals, fisheries, and so on; it deteriorates property to a large extent; and, as interfering with a main source of water supply, is of serious detriment to public health.

"That the value of the solid portions of sewage being small, all attempts at realizing profits from its preparation as manure have signally failed, but, mixed with ashes, sweepings and other dry refuse of towns, sale is found for it at 2s. or 3s. per ton, which is sufficient to pay a proportion of the necessary working expenses of mixing.

"That the most beneficial and most profitable method of disposing of sewage, where circumstances will admit of this use of it, is by direct application in the liquid form to land; where such applications can only be conveniently effected near habitations, it may be desirable to employ some deodorising agent; but usually, if proper arrangements are made for conveying sewage on the land, this expense need not be incurred."

While in their third and final report issued in 1865 they embodied the following conclusions as the results of their labours, extending over 8 years.

"The right way to dispose of town sewage is to apply it continuously to land, and it is only by such application that the pollution of rivers can be avoided.

"That financial results of a continuous application of sewage to land differ to under different local circumstances; first, because in some places irrigation can be effected by gravity, while in other places more or less pumping must be employed; secondly, because heavy soils (which in given localities may alone be available for the purpose) are less fit than light soils for continuous irrigation by sewage.

"Where local circumstances are favourable, and undue expenditure is avoided, towns may derive profit, more or less considerable, from applying their sewage in agriculture. Under opposite circumstances, there may not be a balance of profit; but even in such cases a rate in aid, required to cover any loss, needs not be of large amount.

"Finally, on the basis of the above conclusions, we further beg leave to express to your Lordships' that in our judgment, the following two principles are established for legislative application:—

"First, that whenever rivers are polluted by a discharge of town sewage into them, the towns may reasonably be required to desist from causing that public nuisance.

"Second, that where town populations are injured or endangered in health by a retention of cesspool matter among them, the towns may reasonably be required to provide a system of sewers for its removal.

"And should the law, as it stands, be found insufficient to enable towns to take land for sewage application, it would, in our opinion, be expedient that the Legislature should give them powers for that purpose."

In the meantime a Select Committee of the House of Commons had been appointed to enquire into the same subject. They issued two reports advising the utilisation of sewage on land, and declared that "solid manure cannot be manufactured from town sewage with commercially profitable results."

In 1865 a Royal Commission was appointed to enquire into the pollution of rivers. They came to the conclusion that irrigation on land was the proper method for the disposal of sewage, and pointed out (in their report on the River Lea) that "sewage irrigation works cannot be too simple in their character; the application should be by surface carriers, not by under-ground piping and hose and jet," and that "proper irrigation and cultivation neither fouls the land nor exhausts it. Where sewage irrigation is the cause of a nuisance it will be found to proceed either from use of old and putrid sewage in large and foul open ditch-like carriers, or from open tanks and large carriers being allowed to become foul."

In 1868 another Royal Commission was appointed to enquire into the best means of preventing the pollution of rivers. They made a long series of most important investigations and issued six exceedingly valuable reports. In their first report issued in 1870 they described the results of a series of experiments on the treatment of sewage by means of chemicals, by intermittent downward filtration, and by irrigation, and came to the conclusion that chemical processes might be useful for the preliminary treatment of sewage, but that for purification it was necessary to resort to intermittent downward filtration through soil, or to irrigation over a larger area of land. They also recommended a list of standards of purity, defining the conditions under which waste water discharged from towns or from factories should be considered polluting liquids.

In their second report (1870) they described the results of a special enquiry into the "A. B. C." process for precipitating sewage, from which they came to the following conclusions :—

"1. The process removes a large proportion of the suspended impurities from sewage, but on no occasion, when we have seen it in operation, has this removal been so complete as to render the effluent sewage admissible into running water.

"2. The 'A. B. C.' process removes a very small proportion of the soluble polluting matter from the sewage. After treatment by this process, the effluent sewage is little better than that which is obtained by allowing raw sewage to settle in subsidence tanks.

"3. The manure obtained by this process has a very low market value, and cannot repay the cost of manufacture.

"4. The manipulations required for the extraction and drying of this manure are attended with a nauseous odour, especially in warm weather, and would occasion a serious nuisance if the works were situated in or near a town."

And they remark, "It would obviously be rash to set any bounds to the possibilities of chemistry. Substances may, perhaps, be hereafter discovered capable of combining with and rendering insoluble the filthy constituents of our town drainage; but we are compelled to admit that the present resources of this science hold out no hope that the foul matters dissolved in sewage will be precipitated and got rid of by the application of chemicals to the offensive liquid. The chemical affinities of these foul matters are so feeble, and the matters themselves are dissolved in such enormous volumes of water, that their precipitation is a problem of extreme difficulty."

"Irrigation is the only process for cleansing sewage which has stood the test of experience, and unless it be extensively adopted there is but little hope of any substantial improvement in our sewage polluted rivers." They then contrasted the results produced by the "A. B. C." process for precipitating sewage, with those produced by irrigation on land, and concluded "we have therefore no hesitation in recommending irrigation as the only plan of dealing with the sewage difficulty at present known to us which at once abates a nuisance and turns to profitable account an otherwise valueless material."

Their third report (1871) related entirely to pollutions arising from manufacturing processes.

In their fourth report (1872) they recommended "that any law having for its object the prevention of river pollution should—

"Absolutely forbid under adequate penalties the casting of solid matters into river channels.

"Enact the foregoing standards of purity below which any liquid discharges into watercourses should also be forbidden.

"Give power to all manufacturers in towns, except those of gas, paraffin oil, pyroligneous acid, and animal charcoal, and workers in metal, to discharge their drainage waters into the town sewers under suitable regulations.

"Confer additional powers on corporations, local boards, manufacturers, and others, to take land compulsorily under "Provisional Order," for the purpose of cleansing sewage or other foul liquids, either by irrigation, filtration, or otherwise.

Their fifth report (1874) related to pollution from mining operations and metal manufactories, and repeated the recommendations I have just quoted from the fourth report.

Their sixth report (1874) was a most valuable treatise on the domestic water supply of Great Britain, but is not directly connected with our present subject.

The town of Birmingham, being in a difficulty as regards its sewage disposal, appointed a Committee to investigate the matter. This Committee enquired into the various processes in use at different places, and issued in 1871 a valuable report, from which I extract the following paragraphs :—

"The conclusion the Committee have arrived at is that systems of precipitation are so uncertain that satisfactory results cannot be relied upon, or so inadequate to the requirements of a great bulk of sewage matter that they cannot be justifiably recommended for application to the sewage of Birmingham.

"Irrigation may be thus described :—Land is a natural filter, and, if the purification of sewage alone is contemplated, a comparatively small area, used simply as a filter bed, may suffice, if the filtration is intermittent, to purify sewage so as to allow of its admission into a running stream, but if it is also required to utilize the elements of fertility which the sewage may contain, a vastly larger area is necessary, if the sewage is to be applied so as to produce the greatest return in the shape of *Marketable crops*, without injuring the permanent fertility of the soil.

"The plan which, after the fullest enquiry and consideration, the committee recommend for adoption is that of *Purification* of the sewage by *Intermittent Downward Filtration*; in other words, the application of sewage to a moderate quantity of land, so as to make purification the first object, and cultivation only the second, with the view of passing the purified effluent water as quickly and cheaply as possible into the river."

The Committee gave the following analysis of the answers they received from various towns where the system of irrigation is adopted:—

"1. That the land improves greatly under irrigation.

"2. That, as a rule, no complaints are made of nuisance arising therefrom. In the few instances in which nuisance has arisen, it has been the result of carelessness in conducting the irrigation.

"3. The health of the district where irrigation is carried on is not injuriously affected.

"4. Cattle thrive on the irrigated land, and no case of their being affected with entozoa has ever been heard of.

"5. No other manure has been found necessary for the crops, and the produce, both in quality and quantity, is very satisfactory.

"6. The water, after passing through the land, is purified in a satisfactory manner, and in one case cattle drink the effluent water."

And they finally came to the conclusion "that the best method of dealing with the sewage of the borough is that of intermittent downward filtration on the smallest possible area of land, at the greatest convenient distance from the outfall, so as to command as large an area as possible for the ultimate utilization by farmers."

In 1869 the British Association appointed a Committee to investigate the subject of the "Treatment and Utilization of Sewage." The labours of this committee extended over 3 years, and they issued as many reports. This Committee devised a more accurate method of obtaining average samples of sewage and effluent water than that usually adopted; viz., by gauging the rate of flow at the time each sample was taken, and mixing the samples in proportion to the quantities of liquid flowing.

They also made quantitative experiments during 5 years at Breton's Farm, near Romford, by which they were able to show the total amount of nitrogen contained in the sewage, and how much of it was recovered in the various crops. The average result during the five years being that nearly 33 per cent. of the nitrogen delivered on to the farm in the sewage was recovered in the crops.

In their fifth report they formulated a series of conclusions, among which are the following :—

"With regard to the utilization of sewage, the Committee has come to the conclusion that the precipitation processes that it has examined are all incompetent, and necessarily so, to effect more than a separation of a small part of the valuable ingredients of the sewage, and that only a partial purification is effected by them. Some of them may, however, be useful as methods of effecting a more rapid and complete separation of the sewage sludge.

"The upward filtration process only effects a clarification of the sewage and is therefore no solution of the question.

" Weare's charcoal-filtration process, as carried on at Stoke-upon-Trent Workhouse, did not give satisfactory results, the effluent water being in effect weak sewage; an opportunity will, however, soon be given for an examination of this process in a modified form on a much larger scale at Bradford, and under more favourable conditions.

" Intermittent downward filtration through soil has been shown at Merthyr Tydfil to afford a means of purifying the sewage under favourable conditions; but it cannot be said to be a method of utilization except to a very partial extent, as the investigations made by the Committee showed that the effluent water contained as much nitrogen as was originally in solution in the sewage, but mainly as nitric acid instead of as ammonia and organic nitrogen. There can be no doubt that the process would prove useful as an adjunct to irrigation, or where a sufficient amount of land for irrigation cannot conveniently be got.

" By properly conducted sewage irrigation a solution is afforded to the question of sewage utilization. It has already been stated that a precipitation process, or some clarifying process, may be found useful. If such process, however, removes the phosphates from the sewage, it will, if employed for irrigation, require to be supplemented either by the use of the precipitate produced in the settling-tanks, or by that of some other manure supplying phosphoric acid.

" In all instances it is essential that the land should be well underdrained, and that the sewage should all pass through the soil, and not merely over it, otherwise, as has been shown, it will only occasionally be satisfactorily purified.

" The catchwater, or, as the Committee have termed it, the supersaturation principle, is not defensible either on agricultural, chemical, or sanitary principles.

"An irrigation farm should therefore carry out intermittent downward filtration on a large scale, so that the sewage may be always thoroughly purified, while at the same time the maximum of utilization is obtained.

"It is certain that all kinds of crops may be grown with sewage, so that the farmer can grow such as he can best sell; nevertheless, the staple crops must be cattle food, such as grass, roots, &c., with occasional crops of kitchen vegetables and of corn.

"And it is also certain, from the analysis of the soil, that it becomes very much richer under sewage-irrigation, and that some of the manurial constituents of the sewage accumulate in it.

"Cattle should be fed on the farm. The result would be a vast increase in the production of meat and milk, the great desiderata of the populations producing the sewage.

"Thus the system of farming must be specialised and capital concentrated, the absence of which conditions has proved a great barrier to the satisfactory practical solution of the sewage question.

"The Committee has not been able to trace any ill effects to the health of the persons living around sewage-farms, even when badly conducted, nor is there any proof whatever that vegetables grown thereon are in any way inferior to those grown with other manure. On the contrary, there is plenty of evidence that such vegetables are perfectly suited for the food of man and beast, and that the milk given by cows fed on sewaged grass is perfectly wholesome. To give a recent example Mr. Dyke, Medical Officer of Health of Merthyr-Tydfil, states that since the abundant supply of milk from the cows fed on irrigated grass, the children's mortality has decreased from 48, 50, and 52 per cent. of the total deaths to only 39 per cent., and that, so far from diarrhœa having been made more prevalent by the use of sewaged cabbages, 'last year the Registrar-General called attention to the fact that diarrhœa was less prevalent in Merthyr than in any place in England and Wales;' and he expressed his belief in 'the perfect salubrity of the vegetable food so grown.'

"With regard to the assumption which has been made that entozoic diseases would be propagated by irrigation, all the evidence that the Committee has been able to collect, and more especially the positive facts obtained by experiments, are against such an idea; and the Committee is of opinion that such diseases will not be more readily propagated by sewage-irrigation than by the use of human refuse as manure in any other way, and probably less if the precaution be taken of not allowing the animals to graze, but always having the grass cut and carried to them."

In consequence of the results obtained by the disposal of sewage on land in England, sewage irrigation has been definitely adopted at Berlin, Breslau, and Dantzig. Of the Dantzig farm the late M. Durand Claye, formerly Chief Engineer to the Paris Municipality, exclaims: "It is a truly curious sight to see, surrounded by irregular dunes of blowing sea sand, vast spaces covered with a vigorous vegetation as a result of the application of sewage, and it is of much credit to the Municipality of Dantzig that although the town is surrounded by rivers of large size, and lies within three miles of the sea, it has rejected the false and barbarous system of casting untreated sewage into sea or river."

The town of Pullman, in Chicago, has also adopted sewage irrigation, in spite of the coldness of the winters there, and it has been found to succeed perfectly, although for days together the thermometer is below zero Fahrenheit, and the ground is covered by a stratum of ice from 1 in. to 8 in. thick, under which the sewage continues to flow on to the soil.

Part of the sewage of Paris is also utilized in a similar manner, and a Committee of the Senate is at the present moment investigating the whole question.

A Commission recently appointed by the City of Turin, after carefully enquiring into the whole matter, came to the following conclusions :—

"The chemical or precipitation methods for the treatment of sewage, which have been tried up to the present time, do not succeed in separating the manurial ingredients, are costly, clarify, but do not purify the water, which, moreover, remains liable to undergo putrefaction afresh if the process is not followed by some method of oxidation.

"The only method recognised up to the present time as really efficacious for the purification of sewage is irrigation, carried out in a proper way upon suitable soil. After the separation of the suspended matters this method is deprived of danger and of inconvenience, and in our districts would give the best agricultural results."

While the German Bundestag has actually declined to place irrigation farms for the utilization of town sewage on the list of institutions requiring special permission for their establishment, thus recognising their great importance, and the fact that they need not be a nuisance.

From this review of the various enquiries that have been made in connection with this important subject during the past forty years, it will be seen that all independent investigators have come to the same conclusion.

Nevertheless the sewage of London is still being discharged into the Thames at Barking and Crossness. It was considered, on account of the magnitude of the problem of dealing with the sewage of nearly five millions of people, expedient to make a special enquiry on the subject, and the Royal Commission on Metropolitan Sewage Discharge was appointed in 1882. The composition of this Commission was such as to command the most complete confidence, and after thoroughly enquiring into the whole subject they presented their first report in 1884, in which they formulated the following conclusions :—

"1. That the works of the Metropolitan Board for the purpose of carrying the sewage of London to the respective outfalls at Barking Creek and Crossness, have been executed in a highly creditable manner, and have been of great benefit to the metropolis.

"2. That the storm overflows allow the occasional discharge into the river, within the metropolis, of considerable quantities of solid fæcal matter accumulated in some of the sewers ; but this has not caused, under present circumstances, serious damage or offence.

"3. That the sewage from the northern outfall is discharged partly over the foreshore, and not, as was originally intended, "through submerged pipes, terminating below low-water mark ;" this arrangement increasing the risk of nuisance from the discharge.

"4. That the discharge of the sewage in its crude state, during the whole year, without any attempt to render it less offensive by separating the solids or otherwise, is at variance with the original intention, and with the understanding in Parliament when the Act of 1858 was passed.

"5. That the discharge from the main outfalls becomes very widely distributed, by the motions of the water, both up and down the river, being traced, in dry seasons, through the metropolis, and almost as high as Teddington. And that it oscillates for a long period before getting finally out to sea.

"6. That the dilution of the sewage by the land and sea-water, aided by the agitation produced by the various motions in the river, effects a partial purification of the sewage by oxidation. And that this purification is carried further by the action of animal and vegetable organisms.

"7. That the sewage, which becomes distributed to the higher and to the lower portions of the river, thus gradually loses its offensive properties. The limits, above and below the outfalls, where this purification becomes efficient, vary with the meteorological conditions; but it may be stated that, in general, above Greenwich and below Greenhithe, the river does not afford ground for serious complaint.

"8. That between these limits the effects of the sewage discharge are more or less apparent at all times.

"9. That in dry seasons the dilution of the sewage is scanty and ineffective, especially at neap tides.

"10. That it does not appear that hitherto the sewage discharge has had any seriously prejudicial effect on the general healthiness of the neighbouring districts. But that there is evidence of certain evil effects of a minor kind on the health of persons employed on the river, and that there may reasonably be anxiety on the subject for the future.

"11. That in hot and dry weather there is serious nuisance and inconvenience, extending to a considerable distance both below and above the outfalls, from the foul state of the water consequent on the sewage discharge. The smell is very offensive, and the water is at times unusable.

"12. That foul mud, partly composed of sewage matter, accumulates at Erith and elsewhere, and adheres to nets, anchors, and other objects dropped into it.

"13. That sand dredged near the outfalls, which used to be obtained in a pure state, is now found to be so much contaminated with sewage matter as to be unusable, compelling the dredgers to go farther away.

"14. That for these reasons the river is not, at times, in the state in which such an important highway to a great capital, carrying so large a traffic, ought to be.

"15. That in consequence of the sewage discharge, fish have disappeared from the Thames for a distance of some fifteen miles below the outfalls, and for a considerable distance above them.*

"16. That there is some evidence that wells in the neighbourhood of the Thames are affected by the water in the river; and, although there is no proof of actual injury due to the sewage, that anxiety may be felt on this point.

"17. That there is no evidence of any evil results to the navigation of the river, by deposits from the sewage discharge; but that this discharge adds largely to the quantity of detritus in the river, and so must increase the tendency to deposit.

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* In connection with this I may mention that the Thames was formerly a good salmon river, and that salmon were caught in it at Isleworth as lately as 1835; and also that Dr. Günther, in his "Introduction to the Study of Fishes" tells us that "almost every year salmon and sea-trout in the grilse-state make their appearance at the mouth of the Thames (where the migrating salmonoids have become extinct for many years), ready to re-ascend, and to restock this river as soon as its poisoned water shall be sufficiently purified to allow them a passage."

"18. That the evils and dangers are likely to increase with the increase of population in the districts drained.

"19. That it is desirable we should enquire further 'what measures can be applied for remedying or preventing' the evils and dangers resulting from the sewage discharge.

"20. That before we proceed to this further branch of our enquiry we should allow some time for the consideration of this our first report, and of the remedies which may be suggested for the evils we have pointed out."

It will thus be seen that they make a very serious indictment against the present method of the disposal of the sewage.

They issued their second and final report in the same year. In it they considered six plans for the disposal of the sewage of London. With regard to broad irrigation, they do not recommend it for the disposal of the metropolitan sewage on account of the difficulty of obtaining the enormous amount of land which would be required near the present outfalls, and the powerful opposition that would be made against such a proposal, although on general grounds they recommended it as being "a satisfactory mode of disposal of town sewage," and were of opinion that it need cause no danger to health.

With regard to filtration through land, they considered "that an arrangement of this kind would be applicable to the metropolis."

With regard to precipitation, they concluded "that the cost of treating the sewage of London by a good and efficient chemical precipitation process will entail a cost of not less than £200,000 a year." They considered, however, that "precipitation supplemented by application to land . . . . offers one of the most feasible means of solving the difficulty."

With regard to the proposal to remove the outfalls lower down the river, they stated the following general opinions :—

"1. We do not consider it expedient that the sewage of the metropolis should be discharged in its crude state into any part of the Estuary of the Thames, from the Nore upwards.

"2. But if the sewage were properly clarified by separation of its solids we believe it might be discharged into the lower part of the Estuary, *i.e.*, below Hole Haven, without serious nuisance. In this case the scheme might be made to include an extension of the districts drained."

They do not recommend either of the schemes for the removal of the outfalls to the sea.

The summary of the conclusions they arrived at, and of the recommendations they made, is so important that I cannot do better than quote it in full :—

"1. Our opinion of the evils described in our first report, as resulting from the present system under which sewage is discharged into the Thames by the Metropolitan Board of Works, is much strengthened, and we believe these evils imperatively demand a prompt remedy.

"2. We are of opinion that it is neither necessary nor justifiable to discharge the sewage of the metropolis in its crude state into any part of the Thames.

"3. We are of opinion that some process of deposition or precipitation should be used to separate the solid from the liquid portions of the sewage.

"4. Such process may be conveniently and speedily applied at the two present main outfalls.

"5. The solid matter deposited as sludge can be applied to the raising of low-lying lands, or burnt, or dug into land, or carried away to sea.

"6. The entire processes of precipitation and dealing with the sludge can be, and must be, effected without substantial nuisance to the neighbourhoods where they are carried on.

"7. The liquid portion of the sewage, remaining after the precipitation of the solids, may, *as a preliminary and temporary measure*, be suffered to escape into the river.

"8. Its discharge should be rigorously limited to the period between high water and half ebb of each tide, and the top of the discharging orifice should be not less than six feet below low water of the lowest equinoctial spring tides.

"9. By these means much of the existing evil will be abated.

"10. But we believe that the liquid, so separated, would not be sufficiently free from noxious matters to allow of its being discharged at the present outfalls as a *permanent* measure. It would require further purification; and this, according to the present state of knowledge, can only be done effectually by its application to land.

"11. In the case of the metropolis, the best method of applying the liquid to land, with a view to its purification, would be by intermittent filtration. We have reason to believe that sufficient land, of a quality suitable for this purpose, exists within a convenient distance of the northern outfall. The liquid portion of the sewage would be pumped up to this land from the separating works, and after filtration, would be conducted to the river.

"12. We do not know whether suitable land, in sufficient quantity, can be found in convenient positions near the southern outfall. If not, the liquid must be conveyed across to the north side by a conduit under the river.

"13. If suitable land, in sufficient quantity, and at reasonable cost, cannot be procured near the present outfalls, we recommend that the sewer liquid, after separation from the solids, be carried down to a lower point of the river, at least as low as Hole Haven, where it may be discharged. In this case it will also be advisable that the liquid from the southern sewage should be taken across the river, and the whole conveyed down the northern side. It may be found that the separating process can be effected more conveniently at the new than at the present outfalls; this will depend on various considerations of cost and otherwise.

"14. If the outfalls are removed further down the river, the main conduit or conduits may, if thought desirable, be made of sufficient capacity to include a general extension of the drainage to the whole of the districts round London, as recommended by Sir Joseph Bazalgette and Mr. Baldwin Latham. In new drainage works, the sewage should be, as far as possible, separated from the rainfall."

It will be noticed that these recommendations are perfectly definite, and condemn unhesitatingly not merely the discharge of crude sewage, but also the liquid portion of the sewage after precipitation of the solids, into the Thames at the present outfalls.

Let us now turn to see what has been the action of the Metropolitan Board of Works. One would naturally suppose that after a Royal Commission of exceptional ability had thoroughly investigated the whole subject, had come to certain conclusions, and made definite recommendations, the Metropolitan Board would at once set to work to carry out these recommendations.—Not at all.

In their report for 1884, they state that "the Board, after carefully considering the Commissioners' first report, *felt itself unable to concur in the conclusions at which the Commissioners had arrived*;" thus at the outset, setting their own opinion against that of the Royal Commission.

In their report for 1885 they announced that they had taken the opinions of four independent chemists of the highest standing, as to the processes of deodorisation and precipitation, which were being adopted, and that they advised them "that if the effluent produced by precipitation with lime and protosulphate of iron, be subsequently treated with manganate of soda and sulphuric acid, it will be deodorised and purified to such an extent as to render its discharge into the river unobjectionable at all states of the tide."

But even supposing this to be the case, are Londoners to depend for the purity of the Thames upon the efficient carrying out of a precipitation process, which there will be a strong temptation to carry out inefficiently.

On account of this report, they decided to continue the operation of deodorising the sewage at the present outfalls "whenever necessary, until the establishment of a permanent method of treatment by precipitation." With regard to the disposal of the sludge, they had come to the conclusion that it should be carried away and cast into the sea, and offered a premium of £500 for the best design for a suitable vessel for the purpose.

In their report for 1886, they announced that the precipitation experiments had been so successful that they had decided on extensive works at the outfalls, comprising for the northern outfall alone "the construction of precipitating and sludge-settling tanks, the erection of a pier and jetty, engine and boiler house, places for preparing the lime and iron-water to mix with the sewage, workshops, store-sheds, superintendent's house, and workmen's cottages;" and that they had signed a contract for the construction of a vessel (to cost £15,750), for the purpose of carrying the sludge out to sea, and there discharging it.

In their last year's report, they recapitulated most of their previous statements, and added that they had consulted Sir Henry Roscoe, with regard to the deodorisation of the sewage at the outfalls; but that eminent chemist, in reporting on the results of his investigations, has given them the following significant warning:—

"I offer no opinion as to the processes of precipitation by chemical treatment, as this question was not submitted to me by the Board. Looking, however, at the broad question of the permanent disposal of the metropolitan sewage, and believing that the use of deodorants ought to be regarded as only a temporary expedient, I feel convinced that sooner or later the recommendations of Lord Bramwell's Commission (see Conclusions, etc., 10 and 13, in the Report of the Royal Commission), will have to be adopted, and that the sewage, whether previously clarified or not, must either be filtered through land, or discharged into the estuary at a point not higher than the sea reach. The growth of the metropolis during the quarter of a century which has elapsed since the adoption of the present main drainage and outfall system, has been so enormous, that arrangements which worked satisfactorily up to some few years ago, are now found to be inadequate, and will of course become more so as time goes on."

Can anything be more conclusive, or more condemnatory of the action of the Metropolitan Board of Works? A Royal Commission is appointed especially to investigate the matter; the Board, whose duty it is to provide for the disposal of the sewage of London in the best possible manner, calmly ignores the conclusions arrived at by that Commission, and pursues a course condemned by it, while their chosen adviser informs them that sooner or later the recommendations of the Commission will have to be carried out.

I protest in the name of the Society of Medical Officers of Health of the country, against such a state of things, and against the further carrying out of a scheme which, while being enormously costly, will not only not settle the question, but will rather increase the difficulties of settling it effectually, and will be pointed out by succeeding generations as a disgrace to the sanitary work of the 19th century.

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